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Analysis of Heavy Metals in Soils around a Scrap Metal Recycling Company in Ile-Ife, Osun State, Southwestern Nigeria

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Abstract

Contamination of soils by heavy metals has severely increased over the last few decades due to industrial wastes and human activities. Contaminated soils can constitute sources of health hazard to humans globally. However, there is paucity of information on the level of heavy metal concentration in the study area. This study therefore made a pioneering effort in investigating the concentration of selected heavy metals (Cd, Cu, Pb, Zn and Fe) in soils around a scrap metal recycling company in Ile-Ife, Osun State, Nigeria. Thirty soil samples and solid wastes were collected from four sides of the scrap metal recycling company. The samples were air-dried, digested using standard method and analyzed for the selected heavy metals using a flame atomic absorption spectrometer. Results of the Atomic Absorption Spectrophotometric (AAS) analysis revealed that for heavy metals, the concentrations in the soils were below the background levels and permissible limits recommended for soils in some countries. The value of the mean concentration of the analyzed heavy metals in the soils around the scrap metal recycling company ranged from 0.0040 – 0.0140 mg/kg for Cd, 0.061 – 0.108 mg/kg for Fe, 0.037 – 0.047 mg/kg for Cu, 0.003 – 0.0064 mg/kg for Pb and 0.019 – 0.121 mg/kg for Zn. The results from the study indicated that the concentrations of heavy metals around the scrap metal recycling company did not appear to be of serious concern. The concentrations of all the heavy metals were below the background level proposed by the World Health Organization (WHO) residential soil standards.

Keywords: Heavy metals, Contamination, Scrap metals, Recycling factory, Atomic Absorption Spectrometry (AAS)

Introduction

Heavy metals pollution in soils has become a major threat over the last decades. Pollution in soils by heavy metals can be as a result of both natural processes such as weathering of minerals, and human activities such as mining, agriculture, fossil fuel burning, smelting, wastes from industries, among others (Taghipour *et al*., 2013; Namuhani & Kimumwe 2015). In other words, heavy metals can be transported by natural weathering processes such as erosion or dissolution, or as a result of side effects of human activities. For instance, acid mine drainage are due to weathering of rocks, oxides of

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cadmium and zinc are vaporized and released into the atmosphere during smelting, while lead is emitted from automobile exhaust pipes (Tayab, 1991).

Solid and liquid wastes including fumes generated from steel plants and the raw materials being used usually contain remarkable amounts of heavy metals such as arsenic (As), mercury (Hg), lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn), cobalt (Co), nickel (Ni), among others. Soil contamination with heavy metals in terrestrial ecosystem has been recognized as a serious source of environmental health threat. They have the tendency to accumulate in plants and animal tissues, which later enter human food chain. Large concentrations of heavy metals may get accumulated in the human body through food consumption (Namuhani & Kimumwe 2015). If the metals are ingested beyond the permitted concentration, they can cause serious health disorders (Barakat, 2011). However, some heavy metals (also known as trace elements) such as zinc, selenium, copper, manganese, molybdenum, iron, nickel, vanadium are essential in little quantities by organisms to perform vital physiological functions and maintain proper metabolism of the human body (Aisien *et al*., 2013; Thompson *et al*., 2019). As soon as the active lifespan of a product is over, it becomes an old scrap. Examples of old consumer scraps include used beverage cans, junked automobiles and appliances, while examples of old industrial scraps include jet engine blades and vanes, junked machinery and ships, and metal recovered from commercial buildings or industrial plants (Thompson *et al*.,2019). Solid wastes of these scraps are encompassing and are not restricted to yard waste, household chemicals, building materials or demolition materials. In many cities in Nigeria today, scrap metal sites are located in and around human settlements. The ancient town in Yoruba land, Ile-Ife, is not excluded within which the study area is located.

The study area lies within latitude 07°29′59″ N and 07°29′17″ N and longitude 04°28′14″ E and 04°28′47″ E, about 3 km from Ife-Ibadan-Ilesha roundabout and about 5 km from the Obafemi Awolowo University campus main gate, Ile-Ife, Nigeria. The mean annual rainfall of the area is 1220 mm, while the mean annual temperature is 27°C (Balogun & Salami, 1995). The area is characterized with heavy rainfall ranging from 1200 mm to 1500 mm over 8 months of each annual season with a peak in June and September (Adeoye, 2007). There is variation in soil types, but most contain a high proportion of clay and sand, and are mainly dominated by laterite (Sofoluwe *et al*., 2011).

The disposal of metal scraps in most of the cities in Nigeria today is of great concern because it poses dangers to people in contact with the soil, plants and runoffs from these sites (Thompson *et al*., 2019). Consequence upon the need for improved sources of income, minor scrap metal companies are increasing at an alarming rate. The companies are sited at various locations without minding the possible threat they may pose to the public in such environments. Many of these metal scraps have high concentration of heavy metal capable of depreciating the soil, killing soil organisms and also causing harm to both plant and man. All these activities have contributed, in a large extent, to the degradation of soil and reduction in soil quality. The present study aimed at assessing the levels of Fe, Cu, Pb, Zn and Cd, in the soils within the vicinity of a scrap metal recycling company located within Ile-Ife environ, with a view to monitor the impact of the recycling factory on the immediate environment.

Materials and Methods

Soil Sampling, Preparation and Analysis

The study was carried out around the vicinity of the iron and steel recycling factory along Ife-Ibadan express road, Ife Central Local Government Area, Osun State, Southwestern Nigeria. Figure 1 shows the map of the study area and the soil sample points. Sampling points were established at increasing distance of 50 m from the iron and steel recycling factory, Ile- Ife. The transects were located in the four cardinal directions of North (N), East (E), South (S) and West (W) of the factory. The sampling points were established starting from zero meters (factory wall fence) up to two hundred and fifty meters in each of the four directions (Figure 1). Soil samples were collected at 0–15 cm depth (top soil), using a regular soil auger. Similarly, solid wastes from the factory were also collected to check for heavy metal concentration.

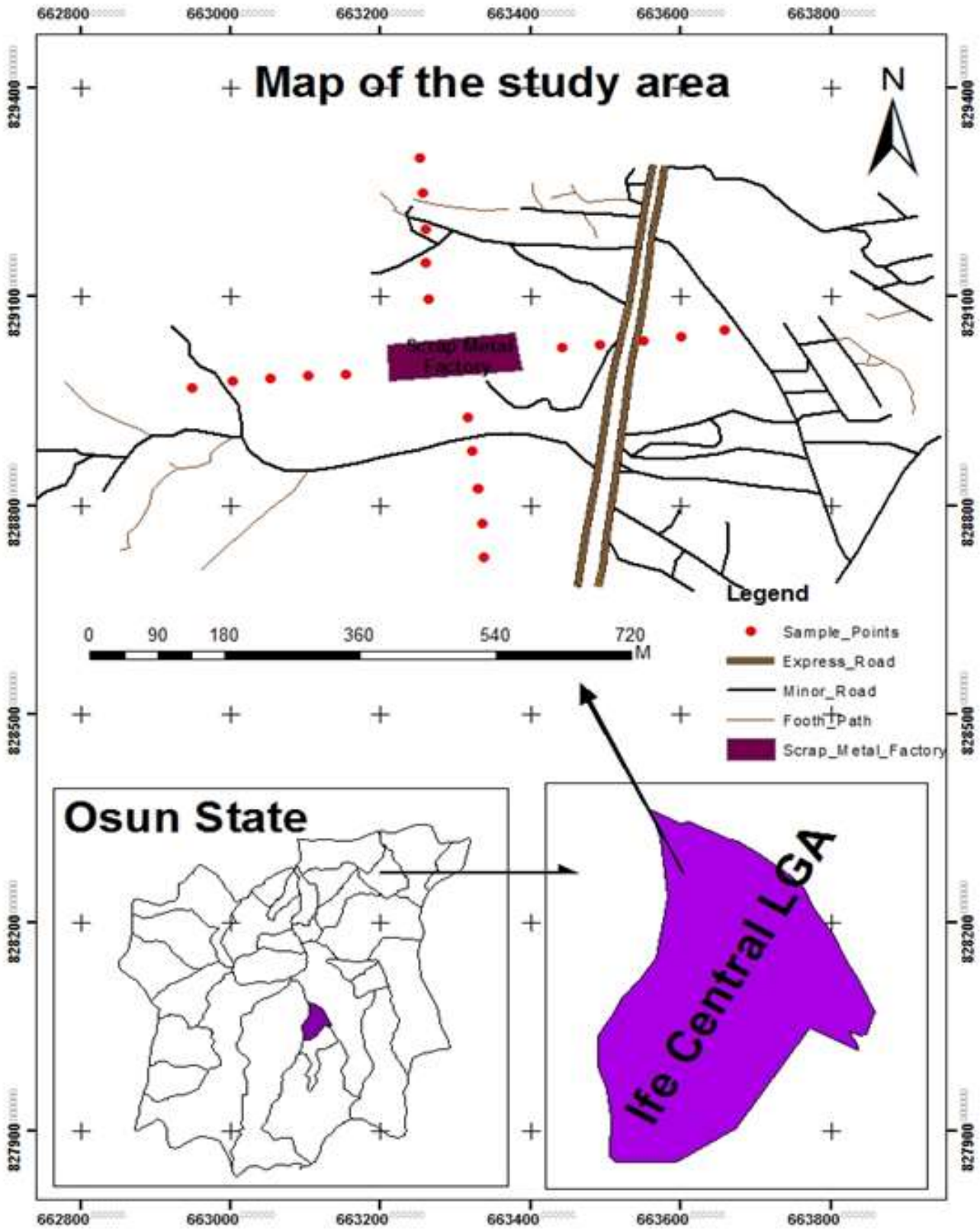


Figure 1: Map of the study area showing the sampling points

At each sample location, a 10 m by 10 m sample point was marked out from where five (5) core soil samples were collected using soil auger in a clean bucket. Before samples were collected, the surface litters were removed at the sampling spot. The core samples were properly homogenized in a clean bucket and foreign materials such as root, stones and pebbles were removed. Each homogenized soil sample was divided into four equal parts in a plastic tray, the two opposite quarters were discarded and the remaining two quarters were remixed and the process was repeated to obtain the desired sample size of 3 kg. Each sample was collected in a clean polythene bag and properly labeled according to the sample location. Soil samples were collected from five (5) locations in each cardinal direction at 50 m interval. Where 1 to 5 represented soil samples collected at 50 m, 100 m, 150 m, 200 m, and 250 m away from the factory's fence, and A1 to A5, B1 to B5, C1 to C5 and D1 to D5 represented samples collected from the north, west, east and south axes of the metal recycling factory respectively. Five control samples were collected from a farm land about 10 km away from the metal scrap factory represented with E1 to E5. Five (5) samples were collected from the solid waste from the factory deposited at the back of the metal factory represented with F1 to F5.

The collected soils were taken to the laboratory, each soil sample was spread on a clean sheet of unprinted paper after breaking the large lumps that were present and allowed to air-dry. The samples were pounded with wooden portal and pestle, sieved to obtain 2 mm soil size sample and then stored in clean polythene bags properly labeled for laboratory analysis. To each sample (0.5 mg) put in a beaker, 10 ml of acid mixture (perchloric/nitric acid) in the ratio 2:1 was added and heated for about 30 minutes to undergo digestion until it turned colourless. The digest was made up to 25 ml with distilled water and analyzed for Iron (Fe), Copper (Cu), Lead (Pb), Zinc (Zn) and Cadmium (Cd). The samples were analyzed with PG990 AAS for the heavy metals in the samples by flame atomization. In the process, air-acetylene flame and single element hollow cathode lamp were used and the equipment procedures were thoroughly followed.

Results and Discussion

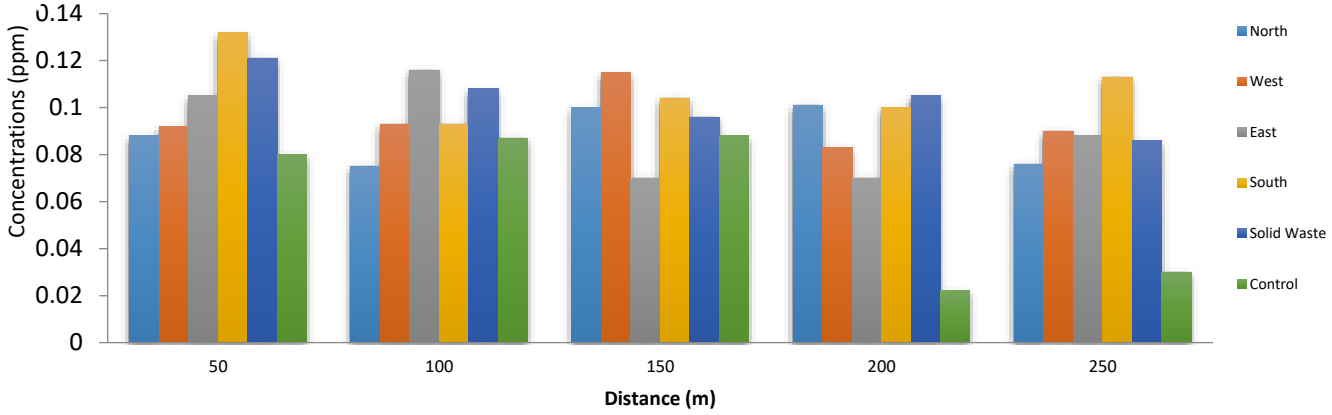
The concentrations of the selected heavy metals (Fe, Cu, Pb, Zn and Cd) in soil samples, the solid wastes from the factory and the control soil samples are shown in Table 1. The range of the mean concentrations of the heavy metals analyzed are Fe: 0.061 ± 0.000 to 0.108 ± 0.002mg/kg for South axis and Control respectively; Cu: 0.037 ± 0.000 to 0.047 ± 0.001mg/kg for South axis and Control respectively; Pb: 0.003 ± 0.000 to 0.064 ± 0.000 mg/kgf or North axis and Control respectively; Zn: 0.019 ± 0.001 to 0.075 ± 0.001mg/kg for South axis and West axis respectively; and Cd: 0.004 ± 000 to 0.014 ± 0.001 for South axis and Control respectively. The mean concentrations of the heavy metals in solid waste ranged from 0.010 ± 0.001 to 0.103 ± 0.002 mg/kg for Cd and Fe respectively, while that of the control ranged from 0.003 ± 0.000 to 0.061 ± 0.000 mg/kg for Pb and Fe respectively. The average abundance of heavy metals in most of the soil samples investigated was of the order Fe> Zn > Cu >Pb> Cd. The result indicated that Cd had the lowest concentration, while Fe had the highest concentration for all the samples analyzed.

Cadmium was detected in all the soils and solid waste from the study area. The mean concentration values of Cd examined at the study area varied from 0.0040 – 0.0140 mg/kg in all the soil samples. They were lower than the natural background level of 0.3 mg/kg reported by (Singh, 2001). Cadmium levels in the study area were also lower when compared to the maximum limit of 0.35 mg/kg by (WHO 2008). The lowest average concentration of Cd (0.004 mg/kg) was obtained for the control soil sample and the highest average concentration of Cd (0.014 mg/kg) was obtained for the southern side of the factory. The Cd concentration (0.018 mg/kg) was highest at the 250 m from the eastern side of the factory and the lowest Cd concentration was obtained for the control soil sample (Figure 2 (a)). This finding of Cd concentration is consistent with that of (Owoade *et al*., 2014), who investigated heavy metals in soils in the vicinity of a scrap metal recycling factory in southwestern Nigeria and obtained most elevated concentration of Cd at the 350 m from the eastern side of the factory. The stream located around this place could responsible for the high concentration of Cd at this side of the factory.

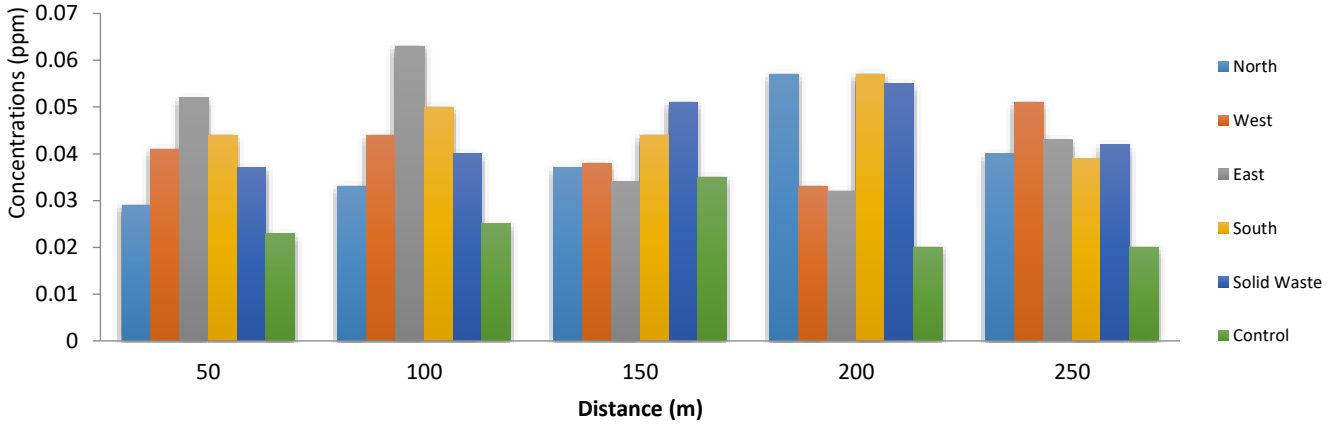
Table 1: Heavy metal concentration (mg/kg) in soil samples and solid wastes around the vicinity of scrap metal recycling company, Ile-Ife

Direction	Sampling points	Conc. (mg/kg) Fe	Cu	Pb	Zn	Cd
North	A1	0.088±0.002	0.029±0.001	0.010±0.000	0.024±0.002	0.008±0.001
	A2	0.075±0.002	0.033±0.001	0.011±0.000	0.022±0.001	0.012±0.001
	A3	0.100±0.001	0.037±0.001	0.009±0.000	0.019±0.002	0.006±0.001
	A4	0.101±0.002	0.057±0.001	0.017±0.000	0.030±0.002	0.012±0.001
	A5	0.076±0.002	0.040±0.001	0.017±0.000	0.026±0.002	0.010±0.001
	Mean	0.088±0.002	0.039±0.001	0.064±0.000	0.024±0.002	0.009±0.001
West	B1	0.092±0.002	0.041±0.000	0.019±0.001	0.022±0.001	0.007±0.001
	B2	0.093±0.002	0.044±0.000	0.013±0.001	0.019±0.002	0.011±0.001
	B3	0.115±0.002	0.038±0.001	0.016±0.000	0.029±0.001	0.009±0.001
	B4	0.083±0.001	0.033±0.001	0.019±0.000	0.010±0.001	0.012±0.001
	B5	0.090±0.001	0.051±0.001	0.010±0.000	0.013±0.001	0.011±0.001
	Mean	0.095±0.002	0.041±0.001	0.015±0.000	0.019±0.001	0.010±0.001
East	C1	0.105±0.000	0.052±0.000	0.003±0.000	0.024±0.000	0.006±0.000
	C2	0.116±0.000	0.063±0.000	0.004±0.001	0.025±0.000	0.010±0.000
	C3	0.070±0.000	0.034±0.000	0.002±0.000	0.023±0.000	0.006±0.000
	C4	0.070±0.000	0.032±0.000	0.002±0.000	0.024±0.000	0.014±0.000
	C5	0.088±0.000	0.043±0.000	0.003±0.000	0.024±0.001	0.018±0.000
	Mean	0.089±0.000	0.045±0.000	0.003±0.000	0.024±0.000	0.011±0.000
South	D1	0.132±0.002	0.044±0.001	0.020±0.000	0.079±0.001	0.017±0.001
	D2	0.093±0.002	0.050±0.001	0.022±0.001	0.070±0.001	0.014±0.001
	D3	0.104±0.002	0.044±0.001	0.021±0.000	0.080±0.001	0.010±0.001
	D4	0.100±0.002	0.057±0.001	0.018±0.000	0.075±0.001	0.015±0.001
	D5	0.113±0.002	0.039±0.001	0.011±0.000	0.070±0.001	0.015±0.001
	Mean	0.108±0.002	0.047±0.001	0.018±0.000	0.075±0.001	0.014±0.001
Solid waste	E1	0.121±0.002	0.037±0.001	0.010±0.000	0.069±0.001	0.013±0.001
	E2	0.108±0.002	0.040±0.001	0.016±0.000	0.077±0.001	0.010±0.001
	E3	0.096±0.002	0.051±0.001	0.022±0.000	0.083±0.001	0.015±0.001
	E4	0.105±0.002	0.055±0.001	0.027±0.000	0.066±0.001	0.007±0.001
	E5	0.086±0.001	0.042±0.001	0.021±0.000	0.073±0.001	0.005±0.001
	Mean	0.103±0.002	0.045±0.001	0.019±0.000	0.074±0.001	0.010±0.001
Control	F1	0.080±0.000	0.043±0.000	0.003±0.000	0.043±0.000	0.005±0.000
	F2	0.087±0.000	0.045±0.000	0.003±0.000	0.042±0.000	0.005±0.000
	F3	0.088±0.000	0.055±0.000	0.002±0.001	0.042±0.000	0.004±0.000
	F4	0.022±0.000	0.020±0.001	0.002±0.000	0.017±0.000	0.004±0.000
	F5	0.030±0.000	0.020±0.000	0.003±0.000	0.019±0.000	0.004±0.000
	Mean	0.061±0.000	0.037±0.000	0.003±0.000	0.033±0.000	0.004±0.000

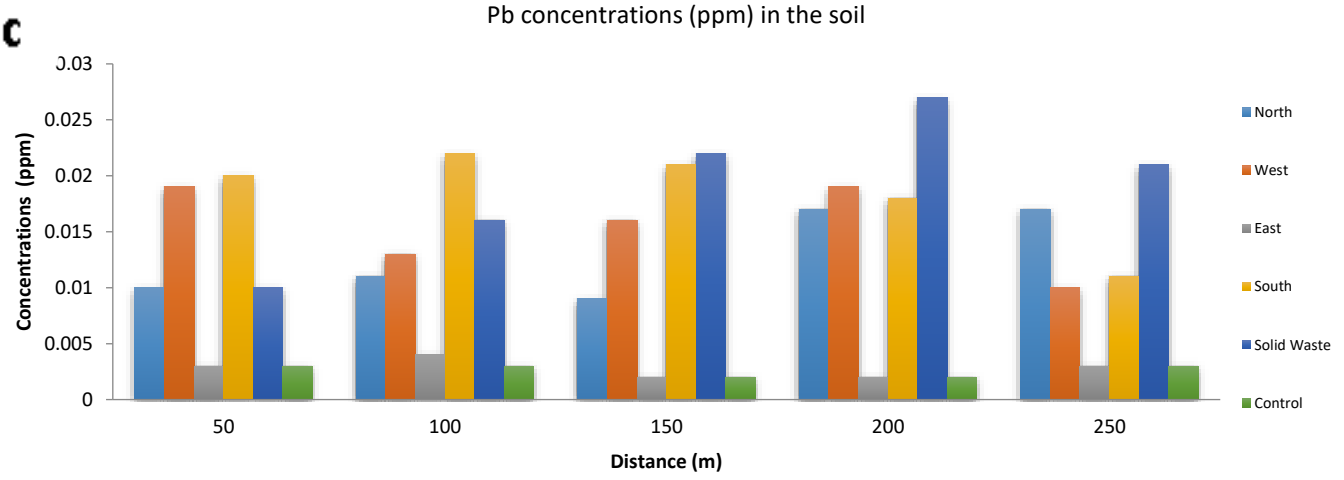
a


Fe concentrations (ppm) in the soil
Concentrations (ppm)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
50
100
150
200
250
Distance (m)
North
West
East
South
Solid Waste
Control

b


Cu concentrations (ppm) in the soil
Concentrations (ppm)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
50
100
150
200
250
Distance (m)
North
West
East
South
Solid Waste
Control

c


Pb concentrations (ppm) in the soil
Concentrations (ppm)
0.03
0.025
0.02
0.015
0.01
0.005
0
50
100
150
200
250
Distance (m)
North
West
East
South
Solid Waste
Control

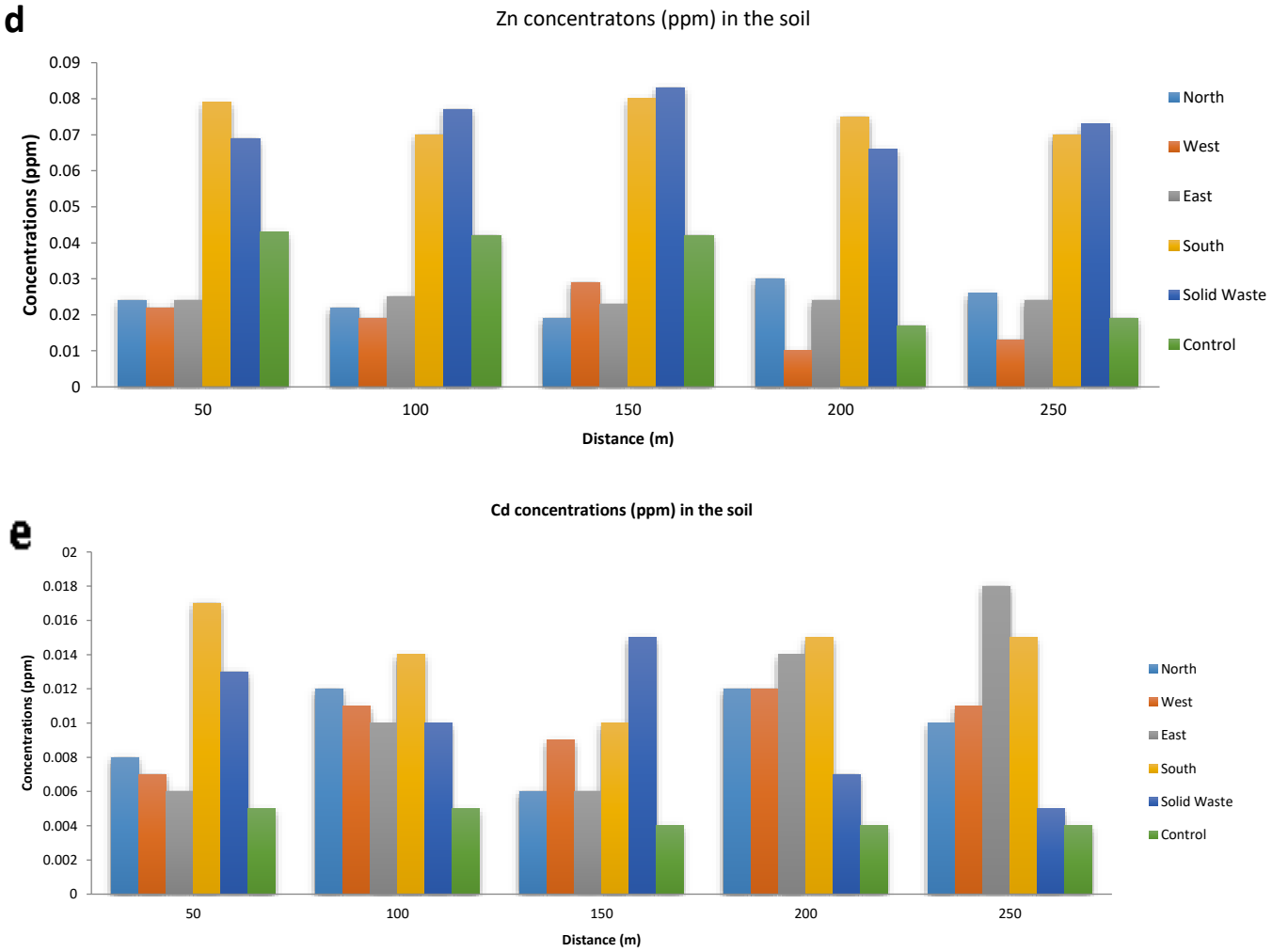


Figure 2: Concentrations (mg/kg) of heavy metals in the soil at varied distances from the recycling company with locations for (a) Fe (b) Cu (c) Pb (d) Zn and (e) Cd

Iron in the soil samples (0.061 – 0.108 mg/kg) was below the natural background level of 0.3 mg/kg for soil (Singh, 2001). The mean value of iron concentration obtained in this study was lower than those reported by (Nwachukwu *et al*., 2011; Idugboe *et al*., 2014; Osakwe & Okolie, 2015). The soil contained high concentration of Fe at the 50 m in the Southern side of the factory. The lowest concentration of Fe was obtained in the control soil sample at the 200 m distance.

Copper was present in all the soil samples investigated from the areas around the metal scrap company. It has a mean concentration value ranging from 0.037 mg/kg – 0.047 mg/kg, with the highest values of 0.047 mg/kg at the Southern part of the area (Figure 2 (c). This therefore revealed that the concentrations of Cu in the study area were below the (WHO, 2008) permissible limit of 30 mg/kg. However, the low level of Cu concentration observed could be due to its mobility in weathering environment and ability to absorb into soil constituents surfaces through ion exchange process (Sanusi, *et al*., 2017). The concentration of Cu at the 100 m in the Eastern side of the factory was higher compared to other sides. The lowest concentration of Cu was obtained in the control soil sample at the 250 m distance.

Lead was found in all the soil samples investigated from the areas around the scrap metal company. Its mean value concentration ranged from 0.003mg/kg – 0.064 mg/kg. The lowest mean concentration of Pb was obtained in the Eastern

side of the factory. The solid waste samples contained highest concentration of Pb at the 200 m away from factory (Figure 2 (d)).The values of Pb concentration in this study were lower than the 1162 mg/kg reported by (Nwachukwu *et al*., 2011) in soils from South East Nigeria and also found lower than the values reported by (Sanusi *et al*., 2017) in soils in the Northern Nigeria.

Zinc was one of the heavy metals detected in all the soil samples investigated from the areas around the metal scrap company. It has a mean concentration ranging from 0.019 mg/kg – 0.121mg/kg, with the lowest values of 0.019 mg/kg at the Western part of the study area and highest average value of 0.121 mg/kg at the Northern side of the scrap metal factory (Figure 2 (e)). The results revealed that the concentrations of Zn in the study area are below the permissible limit of 50 mg/kg recommended by (WHO, 2008). The concentrations of Zn in the soil within the vicinity of the factory follow the trend reported by (Owoade *et al*., 2014).

Conclusion and Recommendation

This study has assessed the level of heavy metal contamination around the scrap metal recycling company in Ile-Ife, Osun State, Nigeria. The results presented the heavy metal concentration in soils and solid wastes around the company. From the data and results of the study, it could be concluded that the concentration of heavy metals around the scrap metal recycling company did not appear to be of serious concern as all the heavy metals analyzed (Cd, Fe, Cu, Pb and Zn) were below the background level proposed by the World Health Organization (WHO). However, Environmental law enforcement agencies such as National Environmental Standard Regulatory Enforcement Agency(NESREA) and Federal Environmental Protection Agency (FEPA) should prioritize monitoring exercise of the activities within the scrap metal recycling company in case of possible high concentration of heavy metal in their site in future.

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